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DISPERSION-BEHAVIOR FOR MICROSTRIP-LINES UP TO 110 GHZ

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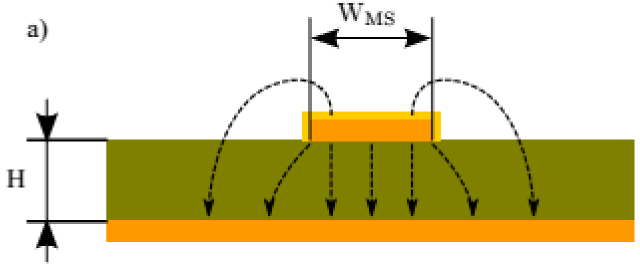
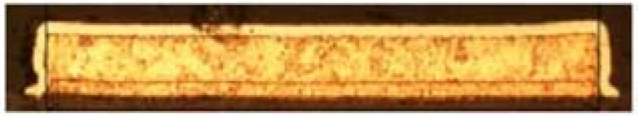
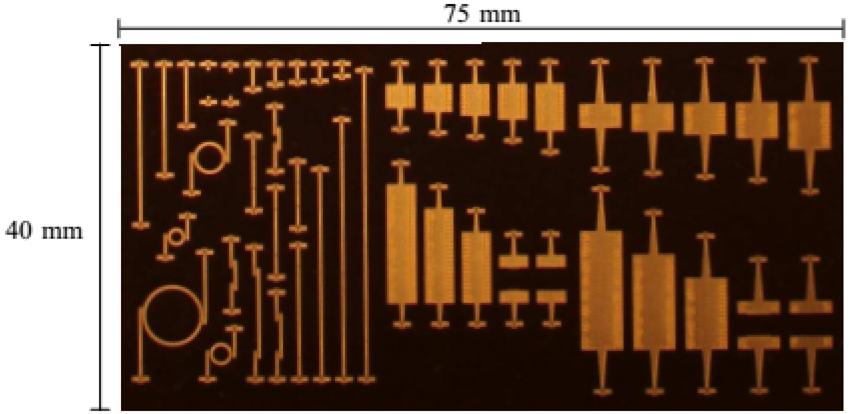
Motivation

- Wafer prober measurements up to 110 GHz
- Commercially available wet-etching process
- RF-Substrate thickness 125 µm (carrier with 700 µm)
- Probe-pitch 100 µm (GSG)

➔ minute launching pads required

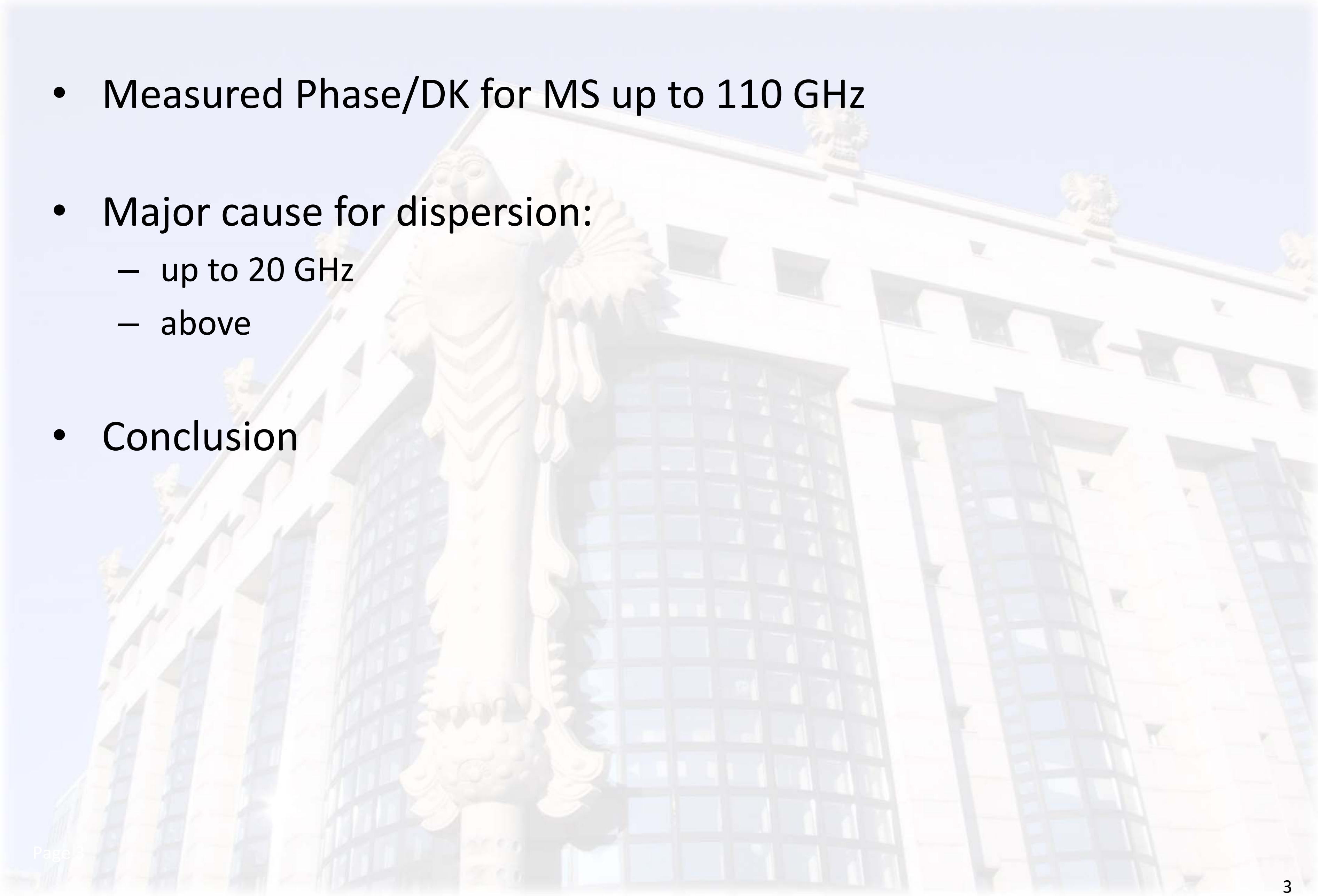






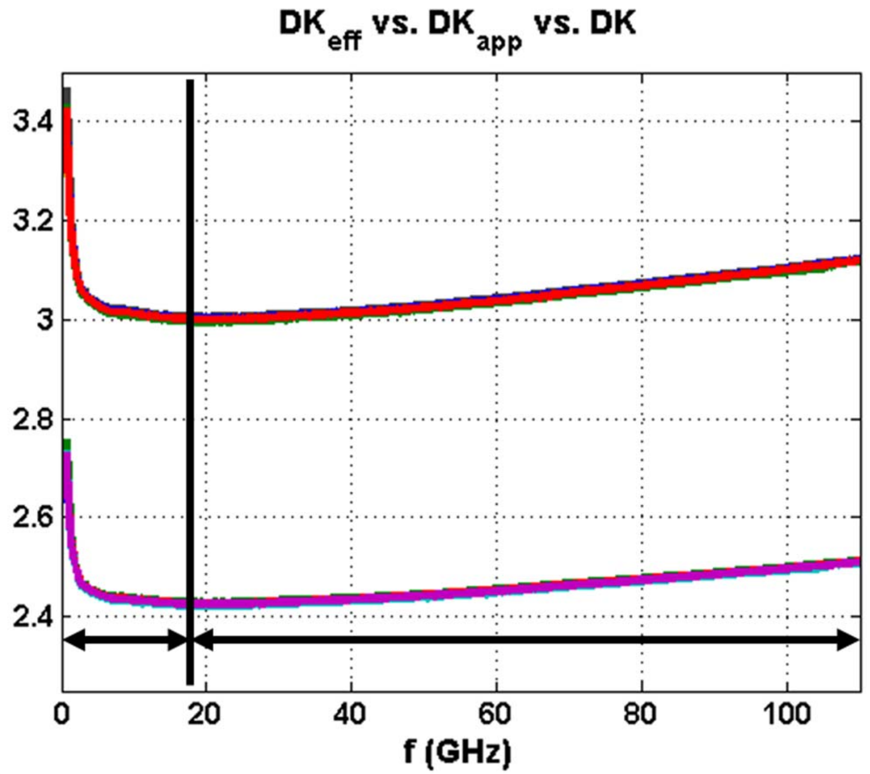
Contents

- Measured Phase/DK for MS up to 110 GHz
- Major cause for dispersion:
  - up to 20 GHz
  - above
- Conclusion

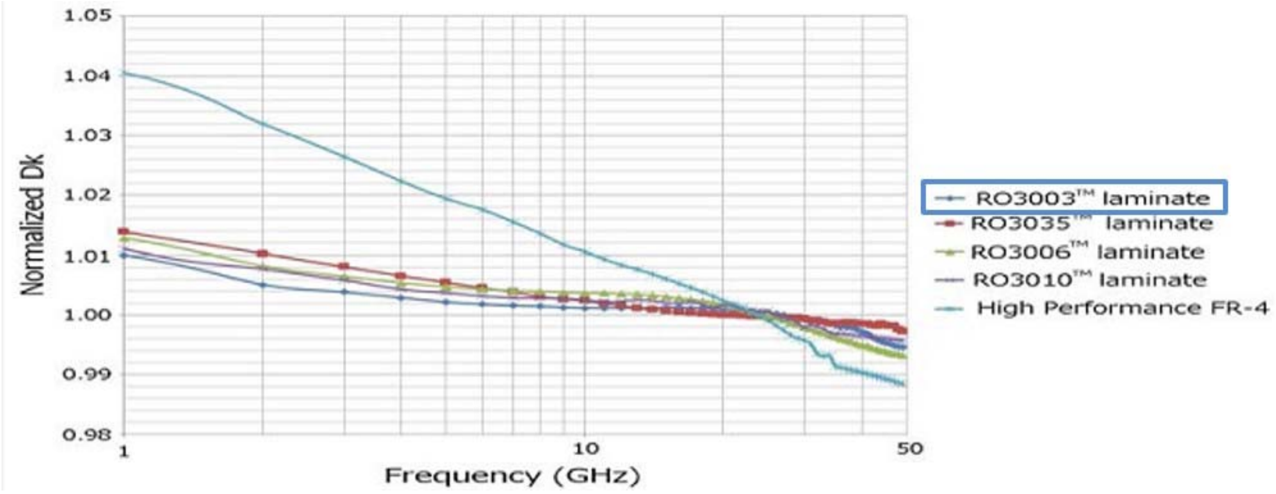


Measured DK for MS

- Strong decrease up to 20 GHz and slight increase up to 110 GHz
- Change of DK within ±1% due to manufacturer
- DK_{app} contains not only dielectric- but also conductor properties



DK_{eff} vs. DK_{app} vs. DK



Measured DK for MS

Apparent permittivity DK$_{app}$ revised:

- Propagation constant:

$$\gamma(w,t) = \alpha + j\beta = \sqrt{(R' + j\omega L')(G' + j\omega C')}$$

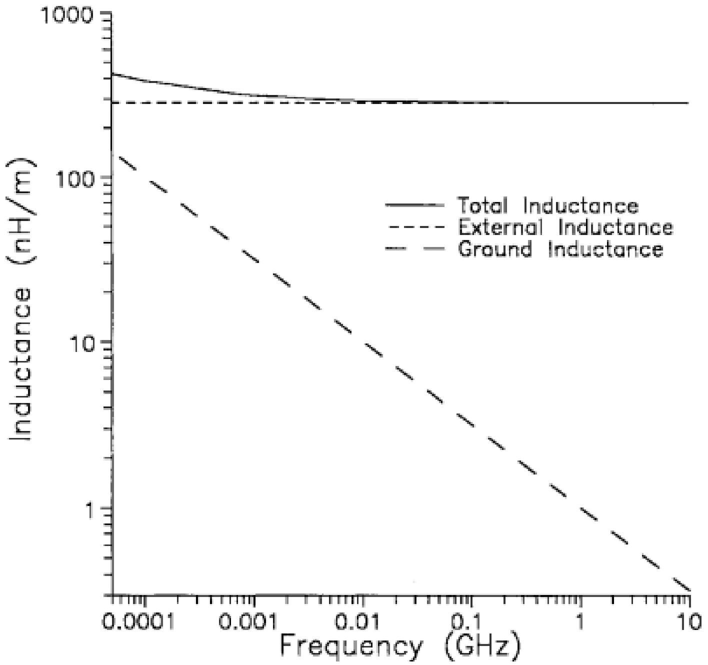
Resistance p.u.l.: $R' = \frac{\rho}{A_{eff}} = \frac{\rho}{w_{eff}(w,t)\delta_{skin}} \rightarrow R' \propto \sqrt{\boldsymbol{f}}$

Inductance p.u.l.: $L' = L'_{ext} + L'_{int}$ with $L'_{ext} = const.\ \&\ L'_{int} = \frac{R'}{\omega} \propto \mathbf{1}/\sqrt{\boldsymbol{f}}$

$$\Rightarrow DK_{r,app} = \left(\frac{\beta c_0}{\omega}\right)^2 = \left(\frac{Im\{\gamma(w,t)\}c_0}{\omega}\right)^2 \rightarrow DK_{r,app}(w,t)$$

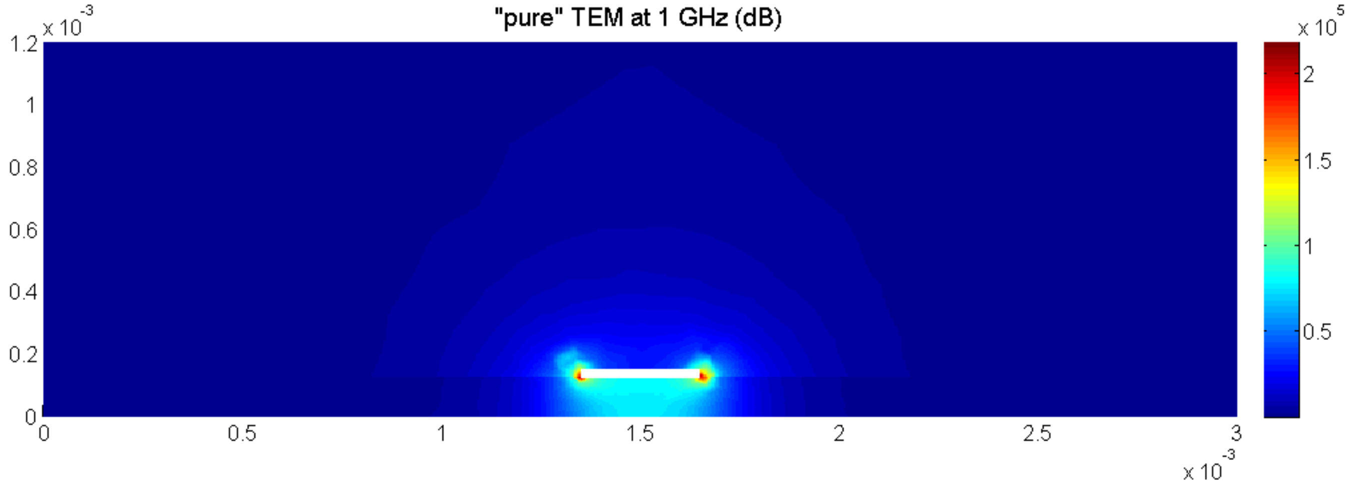
- DK$_{app}$ is coupled to utilized copper cladding (i.e. roughness, thickness, and purity)

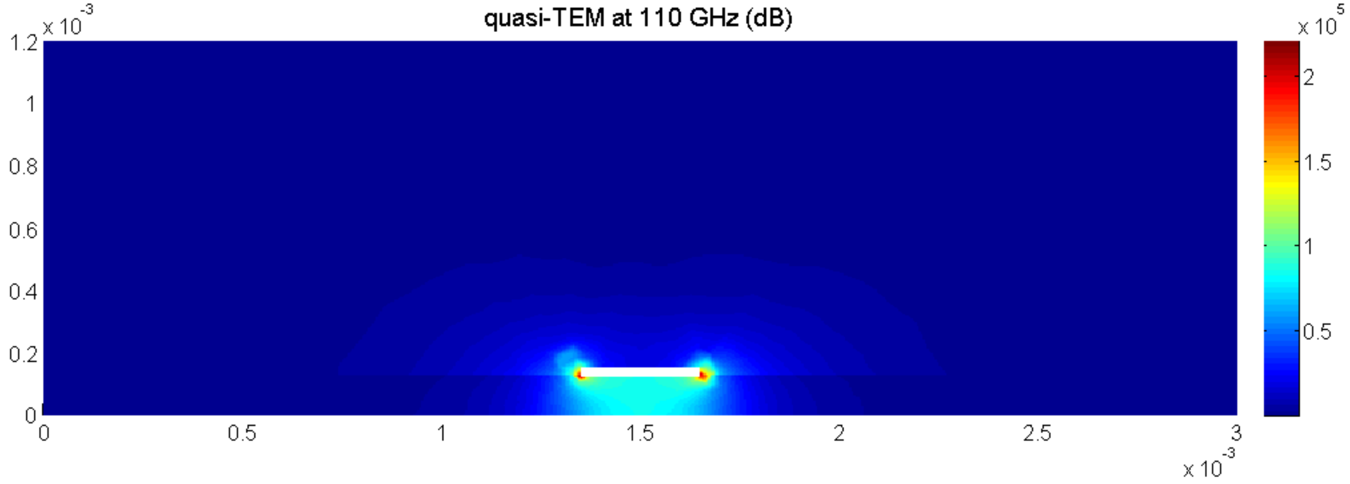
- At certain frequency only surface current present ➔ depends also on surface roughness



E-field dispersion

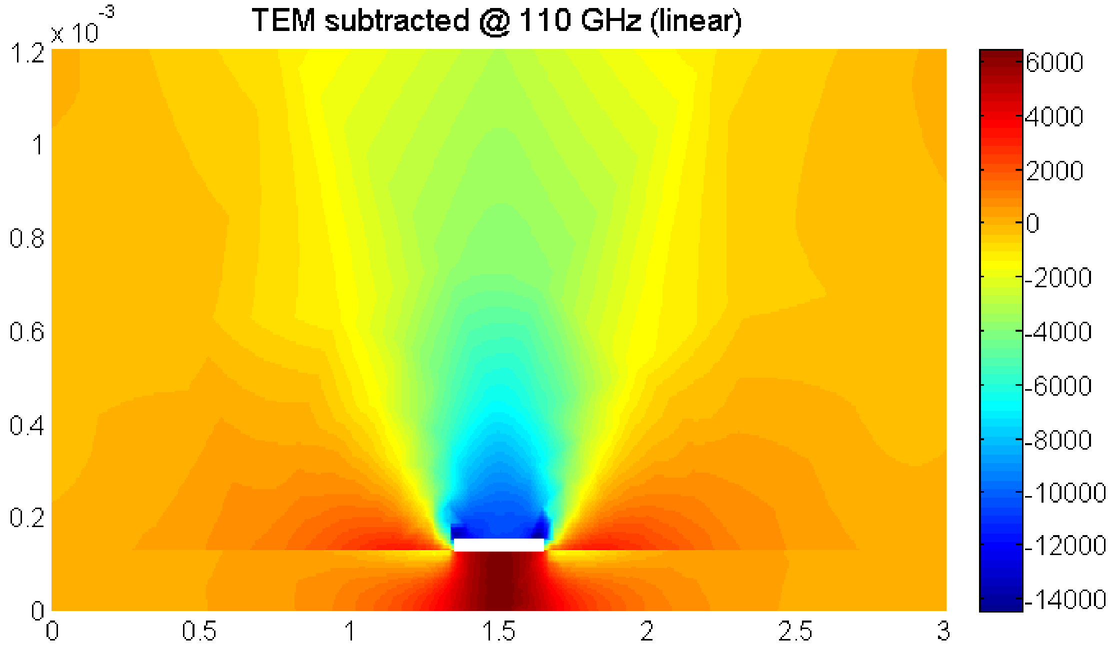
- Dispersion for e.g. electrical field:
  - 1 GHz: significant part of E-field propagates in air
  - 110 GHz: most of E-field is concentrated in substrate

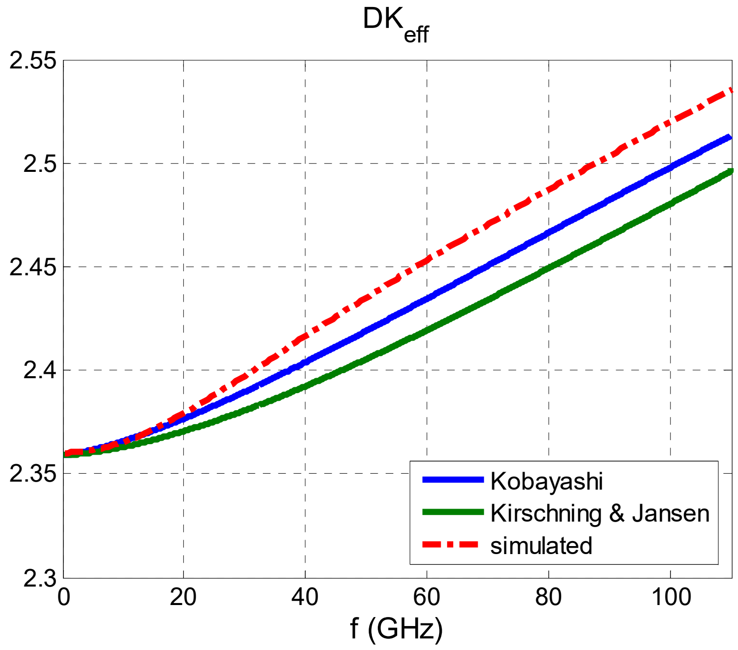




E-field dispersion

- Field pattern for non-TEM mode:
  - “pure” TEM at 1 GHz is subtracted from quasi-TEM at 110 GHz
  - Field magnitude falls drastically above MS-line
  - Compresses into substrate





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Thank you for your attention!